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Hopkinson, Alan (2007) State of the art in RFID technology [in libraries]. Infotheca, 8 (1-2) . pp. 17-22. [Article]

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STATE OF THE ART IN RFID TECHNOLOGY

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Abstract: RFID technology is beginning to be used for keeping track of traditional library materials, whether they be printed, audio-visual, CDs, DVDs, etc.

RFID technology has been used for many years for identifying livestock, tagging children in theme parks in case they are separated from their guardians and for identifying equipment enclosed in boxes. Now it is being used for security and stock control in the retail world and also in the library world.

The RFID chip or tag as it is called can hold substantial amount of data, which will normally include an identifier of the kind which is currently found as a barcode. Additionally it can contain data for unique identification in an inter-library loan scenario; data such as ISBN, class mark and title which can make stock control easier. The latest chips can be written to dynamically so that the data model can be updated as the state of the art in data models advances.

Standards need to be developed specifically for use in the library world and appropriate ISO Committees have begun to develop these. The Danish Standards institution has published a data model and in the UK a joint Book Industry Communication / Chartered Institute of Library and Information Professionals working group has been set up to feed into any international standards work to contribute to the development of an international standard. Unfortunately it is proving difficult to getting international agreement because the Danish Standard which is in extensive use in Denmark has features which countries beginning now do not wish to implement in the same way.

Keywords: RFID; libraries; circulation systems; library management systems; self-service

1. What is RFID?

1.1 Preamble

RFID is a force to be reckoned with in libraries!

RFID replaces the barcode with a piece of wire which has a chip attached to it all encased in a small envelope. This tag is coded with an identifier which could be the same as a barcode and with other identifiers which can be updated dynamically at an RFID pad. This pad can not only read the identifier, it can also write to the tag including writing data to indicate the status of the item ('on shelves', loaned, etc). This is called Radio Frequency Identification.

RFID has been in use for many years. It has been used for identifying items in boxes, and for finding lost children in pleasure parks and missing animals. It is now being used for the control of library materials, with a number of different systems being available which consist of data encoded in a tag which transmits its data to a receiver at the library desk. It can also be used for security control of library materials and people at library gates.

There are a number of different technical solutions which depend partly on the availability of tags of different sizes which have different pricing.

There are a number of advantages over more traditional methods of stock control, particularly barcodes. However, the greater flexibility compared with barcodes leads to more possibilities which come with greater complexity. Already mentioned is the ability to activate security gates.

Other facilities are stock control, sorting books on shelves, and searching for a particular class of item for example books that have been reserved.

The data is not confined only to accession number but other data can be held on the tag, such as title which can be used in an automated returns unit if the equipment goes offline and has no connection to the library database. Therefore standards are required to determine what data should be placed on the tag and when these are established it will be possible to achieve interoperability.

1.2 RFID Components

RFID technology is not new but its widespread commercial application is quite recent because costs have only just fallen to a reasonable level, as the technology has matured and become more widespread. RFID stands for Radio Frequency Identification and in essence consists of a miniature transmitter or receiver incorporated into a device known as a tag, in a moveable item which can be located by a receiver or transmitter which may be stationary or also movable depending on the application. RFID in library systems consists of two items, a transponder (the word is made out of the two words TRANSMitter and resPONDER) consisting of an antenna and a chip and a reader attached to a computer to identify the item. The total package is called a tag or a label. The tag or label is attached to the item to be identified and the reader is, usually, non-moveable or fixed such as in a security gate or incorporated into a library counter or a self-service machine.

Data can be written to the tag, data which can include the data found on a barcode and much more beside; the tags used at Middlesex have a capacity of 1,024 bits. The library circulation workstation has attached to it a pad which can read from a tag and write to it. It will read the accession number or other identifier of a book at the issue station: it will write to a security bit. It can in fact read or write any data element.

As far as library materials are concerned, RFID rivals barcodes as a means of identification and electromagnetic strips as a means of security so RFID can be regarded as dual purpose in that respect. Barcodes have to be read by an optical scanning device such as a light pen; they have to be in line of sight of the reader. RFID tags on the other hand can be placed inside an object for their greater security. For example, IBM have used RFID technology to locate small to medium items of boxed equipment which may be placed inside a carton with a tag attached to the item inside the box but 'visible' to the RFID reader.

They are also used in the retail trade for security: a tag on an item inside a shopping bag can activate an alarm and indicate the item that is being stolen so that it can be identified against goods that have been legitimately paid for. The same methodology can be used in library materials to control their accidental or deliberate unauthorised removal from the library.

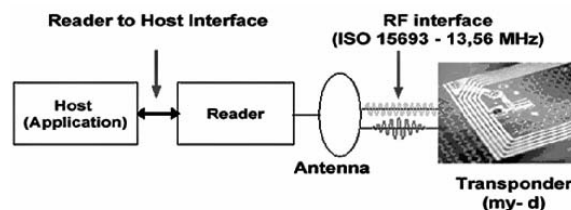


Figure 1. Functions of RFID

The transponder sends radio signal of 13.56 MHz throughout the library via various devices to the reader with the data about the item required for processing a transaction. The RFID radio frequency of 13.56 MHz is approved world-wide for library systems. The transponder is without power, it does not contain any battery, it gets charged temporarily when a reader comes in close proximity within 2 to 18 inches and throws out very small radio signals with the important data from the item. The transponder, which comprises the following four elements, is designed as an RFID-label or tag for library use:

- 1) The chip
- 2) The antenna on a foil
- 3) The cover paper or plastic label
- 4) The silicon liner

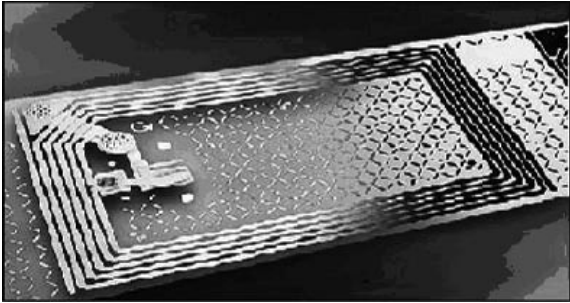


Figure 2. Image of RFID Tag

The reader can have a different designs for library use based on application, for instance: two non-movable antennas with a reading distance of 3 feet between the sensor gates for theft detection, a paper-sheet size antenna on a desk-top reader with an approximately one foot reading distance for discharging and issuing materials and a hand held unit called a wand with a 6 inch reading distance for inventory control or stock verification. Additionally, the readers differ in reading speed and the amount the data that can be read simultaneously as well.

1.3 RFID at Middlesex University

I first encountered RFID at a meeting in 2001 when a representative of Danish Standards said it was vital for libraries to develop standards to enable the smooth implementation of RFID in libraries.

At the IFLA conference in 2003 there was a session on RFID which included Vinod Chakra of VTLS, a well-known US library system vendor recently adopted by Oxford University recently adopted as their Library Management System. I also saw Bibliotheca exhibiting at the conference and was impressed. A week later, I contacted Dynix our system supplier who told me that Bibliotheca had been adopted as the preferred

supplier of RFID solutions for Horizon customers in the UK. Unbeknown to me, our University Librarian had seen RFID in use in libraries in Singapore and was enthusiastic. With the help of Dynix, we organised a demonstration in January when we had an intersemester break for staff at our Hendon campus where we were building a new library and by the middle of September RFID it was operational there. This was a new state-of-the-art building so it was appropriate for it to have a state-of-the-art circulation control technology.

In the meantime we had had to plan to place the tags in 300,000 books at the same time as the old library was closed and staff were preparing to take on the new. The RFID system interfaces with the library management system's circulation model using a protocol called NCIP, NISO Circulation Interchange Protocol. NISO is the American National Information Standards Organization which looks after standards for library systems.

Library users can issue or return their books using their current student card which holds a barcode: the self-issue equipment is supplied with a scanner. The equipment can read up to five items at a time reliably (and in practice more). A stock check in the Hendon Library was achieved by 2 staff working for around three weeks and closing off individual bays one at a time; before with the old method where books had to be opened to access the barcodes, the library was closed for a week and a dozen or so staff had to engage in groups of two in the stock check activity. The perception of library circulation staff was that more books were being stolen under RFID. However, the stock check determined that there was very little difference. This probably demonstrates that certain students will strive to steal books whatever the security system. The security system does of course catch users who take books from the library by mistake; the RFID system is better at detecting this than the old electromagnetic system which could be set off by a mobile

phone with the result that students could show the security staff doing the bag check after the alarm had been set off a mobile phone to deter him from looking more carefully in a bag and by that means take out material. The RFID system on the other hand records any item that sets off the alarm, even if a manual check fails to find it.

2. State of the art in RFID in Libraries

2.1 Extent of usage

In February 2004 there were around six institutions using RFID in the United Kingdom. We needed to make visits before we selected RFID for circulation so we went to Nottingham Trent University and a public library using the Horizon library management system (the system we use) in Switzerland, Winterthur Public Library.

Now usage is increasing in Britain with one of the latest institutions being a new fashion college which has the intention of providing training in technology to students who want to work in the retail trade, perhaps the first college at the further education level to implement RFID.

Systems are provided by 3Ms, Bibliotheca, Intellident and TagSys and provided in most cases via library systems vendors, for example, DS, Geac, SirsiDynix, TALIS.

2.2 Standards

Standards are useful for enabling systems to work together with other. They also obviate the need to reinvent the wheel by giving guidelines which can help to answer questions that suppliers of hardware or software systems may ask.

When we discussed with Bibliotheca how we would implement RFID, they wanted our assistance in developing the 'data model' for our implementation. This is the arrangement of data on the chip. A 'traditional' barcode has its own format and incorporates such elements as check digits, but as far as the link to a library system is concerned it represents just a number. In the case of an RFID tag, there is the possibility to store much more data than a barcode or its rep-

resentation. Codes can be stored which denote the library and the country. These would allow books to be detected if not actually identified by other libraries than the owner library. A byte on the tag can be allocated to an indicator of whether the item is issued or not so that it can cause the alarm to go off. Otherwise, the detection system has to refer to the database to check the status of every tag which passes through which could cause a backlog at the gate if the network and servers were not sufficiently fast, or even temporarily slowed down. Even a title can be stored on the tag so that if a system goes down return receipts can be issued to the users. Normally these data elements have to be read only by the library management system. But there are other possibilities. In Denmark they want to have a common tag which can be read by any library system to facilitate inter-library loan. Danish Standards therefore initiated discussions within appropriate International Organization for Standardization (ISO) committees on the standard. Imagine being able to borrow a book from a library that is not your own using your own readers card (which could also be an RFID card though I hasten to add that a card to identify a person would not be following the standard for library materials). Danish Standards have now published a data model (Danish Standards, 2005) which takes into account input from other national standards bodies. They have obtained agreement for ISO to develop a standard for RFID in Libraries.

So if there this standard had already become available, we would not have had to engage in so much discussion with Bibliotheca.

Barcodes have a particular format. This is of course governed by a standard. Barcode scanners need to be programmed to deal with these formats. The formats have to be compatible with hardware and software in the outside world. The same goes for RFID. The data on the chip has to conform to standards. In addition the equipment needs to know what signals to expect.

There are different standards for tags. Tags can vary according to the radio frequency they transmit. Most library systems currently are using 13.56 MHz. They also vary according to their air interface: there are four different protocols for that. They can also vary according to the conventions used for storing the data.

These issues have to be discussed and agreed on before a standard can be developed.

3. Events in the UK and beyond

A few years ago, Book Industry Communication (BIC), (an organization which has responsibility for communication between the different sectors of the book trade including libraries) proposed on behalf of the booktrade an application of RFID technology. If every book had incorporated into it during production a tag, this could contain data such as the ISBN plus copy number which together would make a unique identifier. This could be used by library systems and equated by means of a table held in the automated library system to its accession number, the identifier in the system often referred to as the barcode. This tag could be used by the publisher, wholesale distribution, retail distribution and the library successively. Because of the cost of RFID tags (currently 25p to 55p) it is best to use them repeatedly. A library will have a great deal of reuse so an RFID tag may be particularly cost effective for libraries, certainly more so than for the retail trade. Read-only tags are cheaper than those which can be constantly changed in their contents. Another scenario could involve a writeable tag being incorporated into publications which could be re-used by different systems. It can therefore be seen that a library would benefit more from RFID being incorporated into a book than the book-trade. RFID as envisaged in this scenario would be most effective if it were incorporated into the majority of books.

Tagging publications universally at the point of production was rejected by the book-trade. Profit margins would have been seriously de-

pleted if tags had been added to books. The main beneficiary would have been libraries who can re-use tags repeatedly as books are circulated and indeed need to be prevented from leaving the library illegally over time. It is interesting to note that the proposal was to place minimal data on the tag and let the tags communicate with the database to determine the status of the items. More recent thinking has recognised that the connection with the database may not always be available and more data should be placed on the tag.

In the UK, BIC kept up its interest in RFID and set up jointly with CILIP¹ the 'BIC/CILIP RFID in Libraries Group' which has organised two conferences and discusses issues outlined above. The Chairman of this group, Martin Palmer of Essex County Council, has been nominated as an expert from the library profession for the ISO Working Group which held its first meeting on 1 December 2006.

One aim of developing a standard is to enable libraries to tag materials and to be sure that if a supplier changes its preferred tags or goes out of business, it will be possible to switch to another supplier without having to retag. One feature of RFID is that you can change the data model dynamically. You can program the writers so that whenever a book is issued it can, if required, have a new data format written to it. For example you could begin to add the class number to a data model where it had not been added before. All this becomes much easier if every system is using the same framework; the system suppliers do not need to keep rewriting their programs. So a standard data model will not force systems to adopt the same data model, just a compatible one.

Nevertheless little progress was made at the meeting in Denmark in 2006. The Danish already had a standard which has been widely adopted in Denmark. It needs to be updated to take into account current requirements elsewhere if it is to be accepted as an international standard, but this would mean that the Danish practices would be non-standard.

4. Impact of RFID on libraries

What effect has RFID had in libraries which have adopted it? Self-issue is in vogue in the UK. It reduces staff time engaged on clerical tasks. It also enables students to have better control of their transactions. Additionally it offers an out of hours service when the library is not staffed.

The wand mentioned above can be used for writing to tags, for example setting the security bit. It can be used for finding books out of place on the shelves (by being programmed to look for shelf marks and detect one which has a lower number than the one which was detected earlier). A list of identifiers can be placed on the Personal Digital Assistant (PDA) linked to the wand and the wand can detect the tags which contain those identifiers. Similarly the PDA can be loaded with the identifiers of books placed on reservation.

Another interesting item which the RFID tags facilitate is the book sorter. Because line-of-sight access to the tag is not required, it is possible for a user to put a book on a pad, cancel the loan, read the type of book and sort it to a trolley.



Fig. 3 Returning a book

Over the last decade, British libraries have introduced self-issue systems and self-return systems. There have been many problems with them particularly as regards the security aspects: most have used electromagnetic security systems. In some universities using electromagnetic systems, they have closed down manual issue desks and forced students to use self-issue systems, in order



Figure 4: Sorting unit.

to achieve a high percentage of self-service, otherwise the accepted usage is around 25%. In the case of RFID self-issue, faster and easier book checking has resulted in much larger proportions of books being returned without staff intervention, over 40% at Middlesex University.



Fig. 5: Self-service unit

Sadly, some students are less than honest and have removed the tags from the books in order to take them out of the library. In many instances these tags have been found when the cleaners removed the waste from the library. They have been told to put aside any rubbish bag and subsequently library staff go through the rubbish looking for the tags. At least they know which books have been stolen! It is also possible to identify and produce a list of books which students attempt to steal since those books are logged at terminals at the library counter.

There are a few disadvantages of using RFID technology, which should be stated.

- RFID technology is more expensive than the more traditional combination of barcode and electromagnetic strip. However, the price of the tags is likely to fall.

- Tags can be removed by vandalism: they are easier to find than electromagnetic strips.

- Tags can be disabled by the book being wrapped in aluminium foil and the book being hidden.

- Tag detection is affected by large metallic devices, such as lifts. Special very expensive tags have been developed for CDs; otherwise metal disks cannot be tagged with the usual tag.

- Privacy issues are not a real concern, but in the United States there are a number of pressure groups which campaign against RFID technology on the grounds that it can constitute an infringement of privacy. They believe that people with RFID readers could track RFID tags attached to books inside readers' carrier bags and determine what books people are reading. Given that data on tags is encrypted and even if it were not there is little data that would enable identification without access to the library database which is only possible with a direct link to the database, it is unlikely that in practice a tag could reveal the item being read. Nevertheless, this has put a damper on implementation in some institutions, though there is no evidence of this in the UK or Europe.

5. Conclusion

RFID technology is here to stay. The advantages of the technology far outweigh the disadvantages. Initially libraries in the UK were slow to consider implementing RFID. They were concerned about costs and the uncertain reliability of a new technology. Additionally it was felt that there would be a huge effort in applying the tags to books. However, at Middlesex University using the Bibliotheca system we were able to tag around six a minute, and tagged the whole book stock of 300,000 items in 6 weeks. Students like the new technology and use it without coercion, freeing staff time for more difficult and time-consuming activities.

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¹CILIP: Chartered Institute of Library and Information Professionals

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